Inelastic X-Ray Scattering Inititative @ APS

E. E. Alp

3-way meeting of APS-ESRF-SPring-8

June 2-3, 2003
Argonne National Laboratory

Plan:

- Scientific agenda
- Institutions and funding
- Current situation at the APS
- Innovations required
- Time table

Scientific Agenda

- Medium Energy Resolution Inelastic X-ray scattering for electronic structure studies in e.g. correlated electron systems:

  MERIX (10-200 meV @ 5-12 keV)

- High Energy Resolution Inelastic X-ray scattering for collective excitations in solids and liquids

  HERIX 1.5 mm @ 21.5 keV,

  1 meV@ 25.7 keV

Institutions

- Akron
- Cornell
- MIT
- Northeastern U.
- Princeton U.
- SUNY-Stony Brook
- U of California
- U of Pennsylvania
- U of Illinois (UIC-UIUC)
- U of Tennessee
- Western Michigan U.
- Argonne
- Brookhaven
- Carnegie Institute of Washington
- Lucent
- Oak Ridge

Chairman of the Executive Committee
M. Klein (UIUC)

Executive Director
J. Hill (BNL)

Current situation at the APS

- **Sector 3ID: dedicated to**
  - 40% inelastic x-ray scattering
  - 60% nuclear resonant x-ray scattering & optics development

  HIGHLY SUBSCRIBED

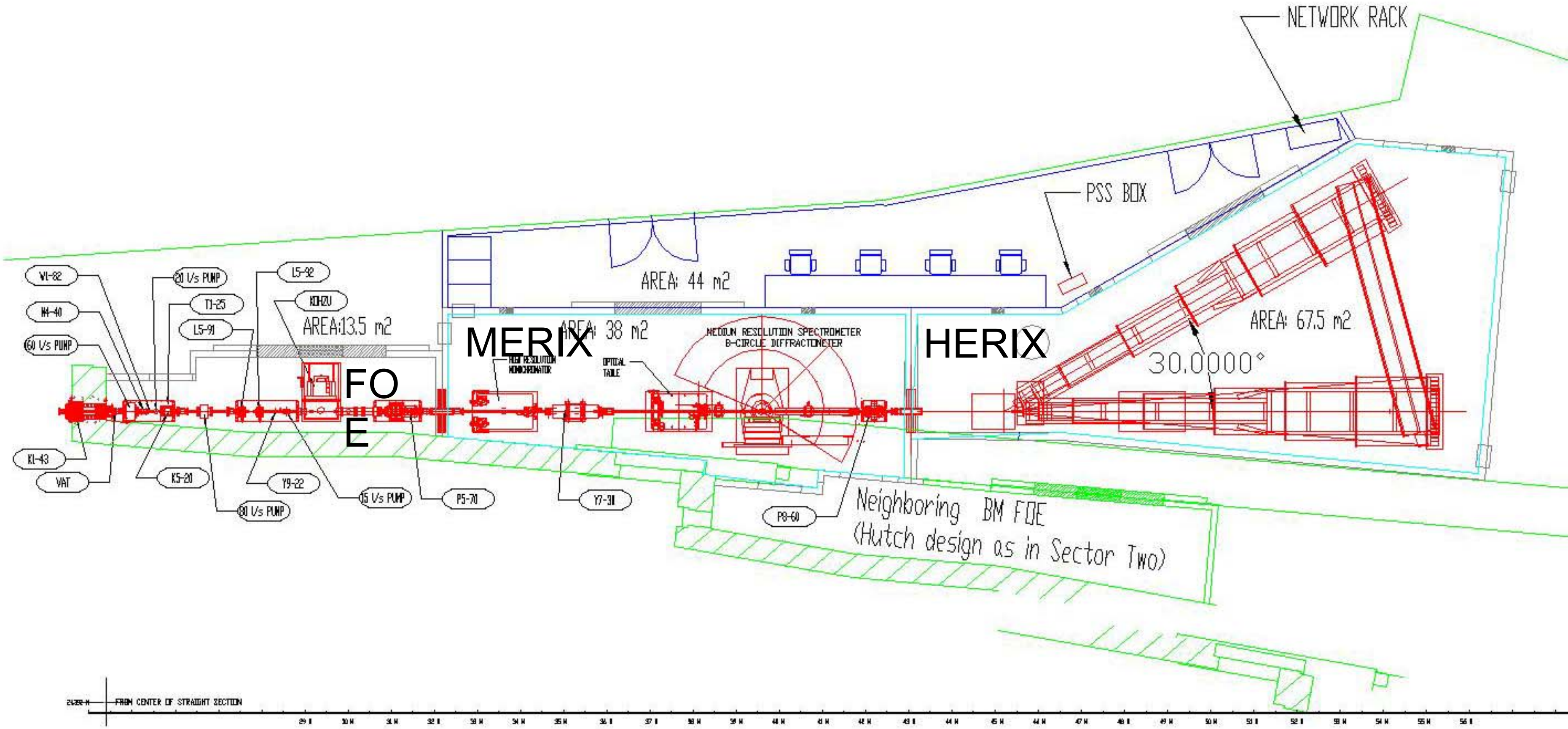
- **Sectors 9 (CMC) ,12 (BESSRC) ,16(HP) and 33 (UNI)**
  - Capable of IXS on a part-time basis

- **Sector 30, the new IXS beamline will be fully dedicated to resonant and non-resonant IXS studies with no development program anticipated**

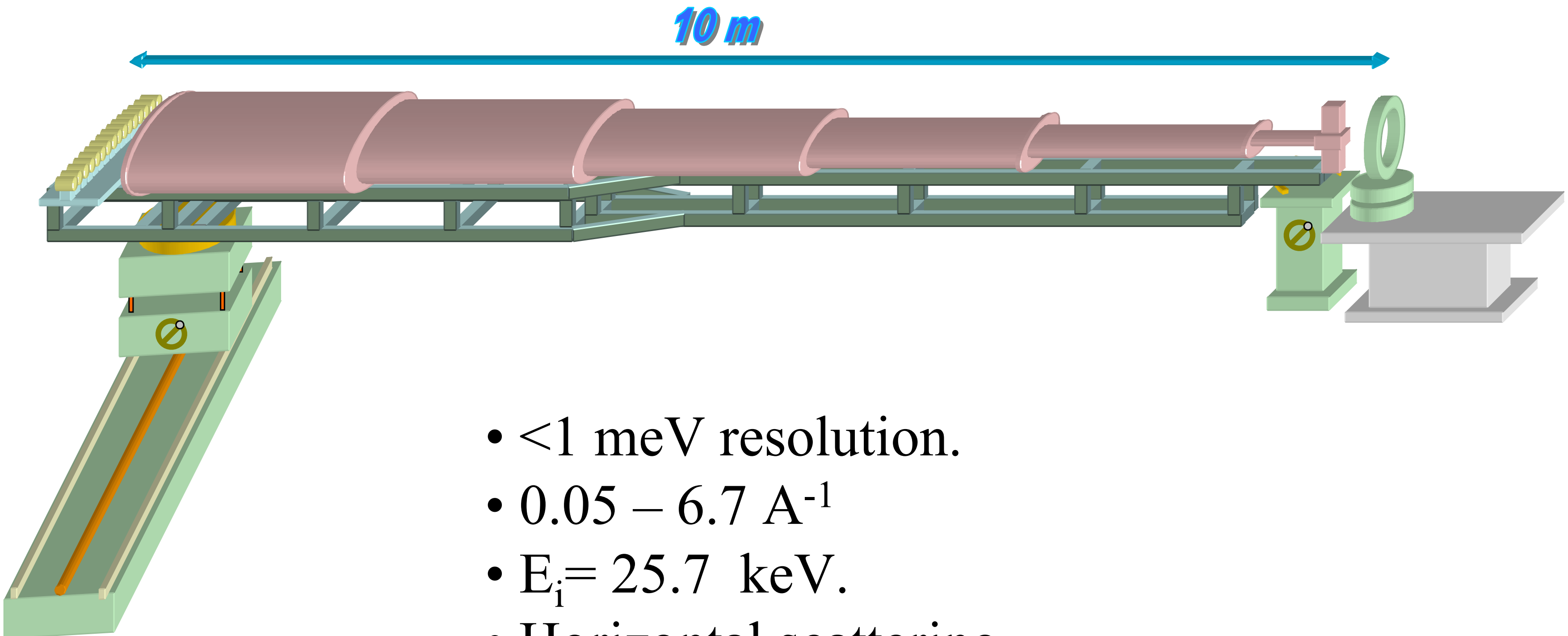
IXS-CDT: *A second generation beam line dedicated for inelastic x-ray scattering*

- A longer straight section (up to 4 undulators)
- Specialized undulators
  - Superconducting undulator with 14 mm period
  - Planar permanent magnet undulators (30 mm)
- Cryogenically cooled high resolution monochromator
- Novel back-scattering analyzers

IXS-SECTOR Layout



HERIX

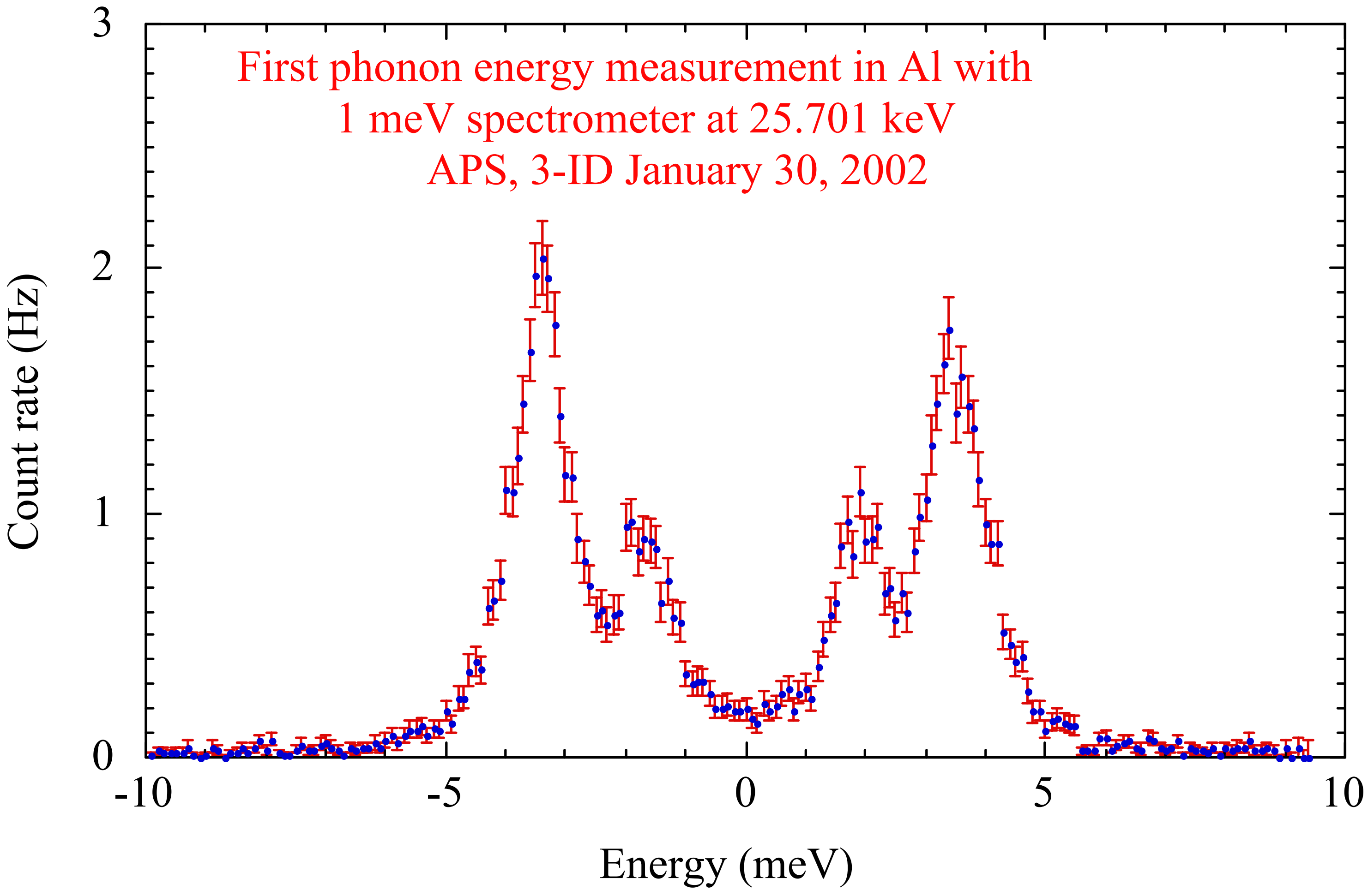


- <1 meV resolution.
- 0.05 – 6.7 A^{-1}
- E_i= 25.7 keV.
- Horizontal scattering (10m arm).
- Multiple Analyzers.
- Cryostats and ovens

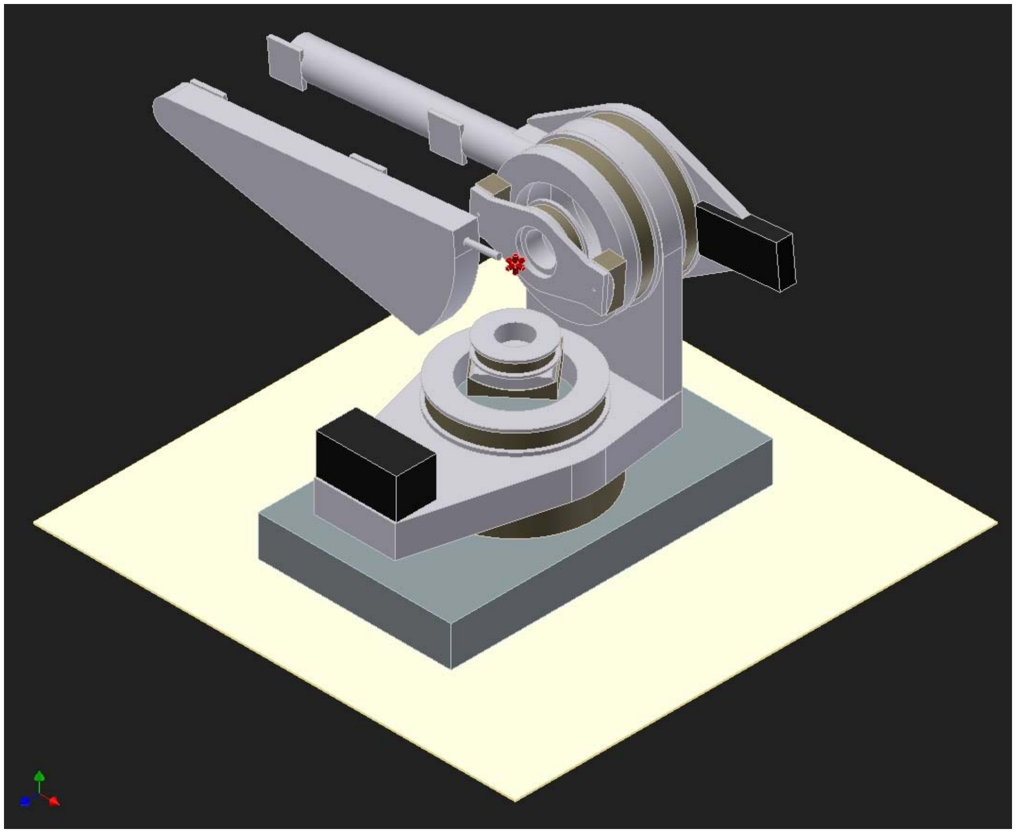
Harald Sinn, Deming Shu

Status: Conceptual design complete, some components ordered.

1 meV IXS spectrometer @ 25.7 keV



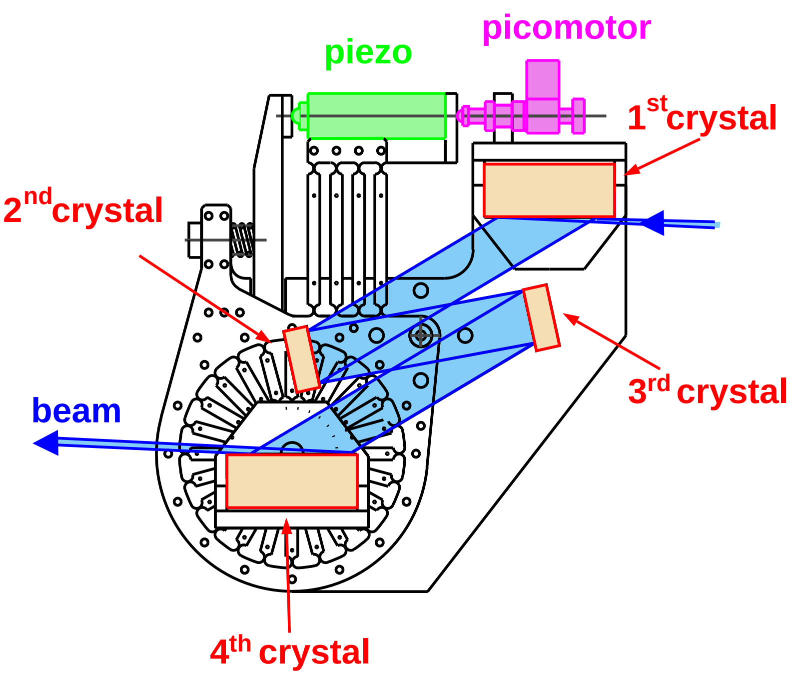
MERIX

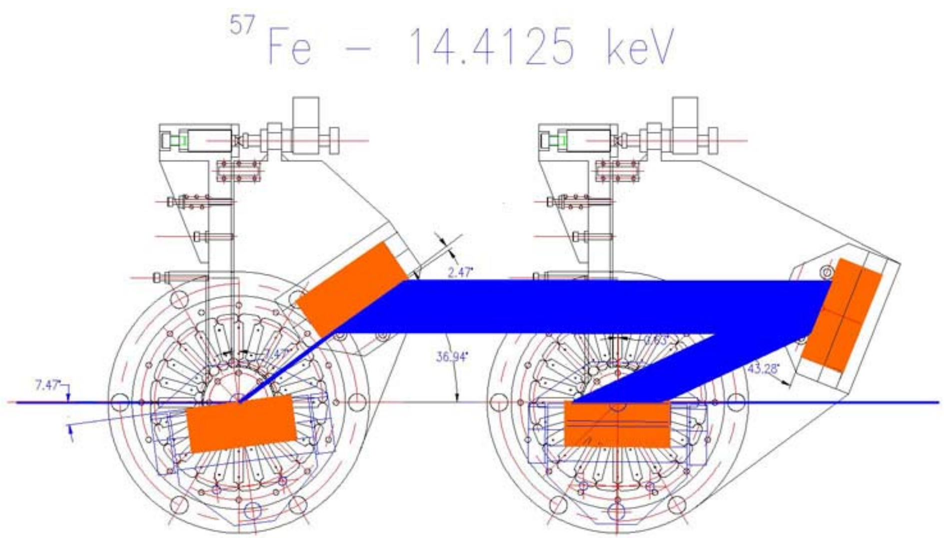


- 100 meV resolution.
- E_i= 4.9 – 11 keV.
- Vertical and horizontal scattering.
- 2m Analyzers.
- Closed cycle cryostats.
- Polarization selective

Clem Burns, Scott Coburn, J. Hill

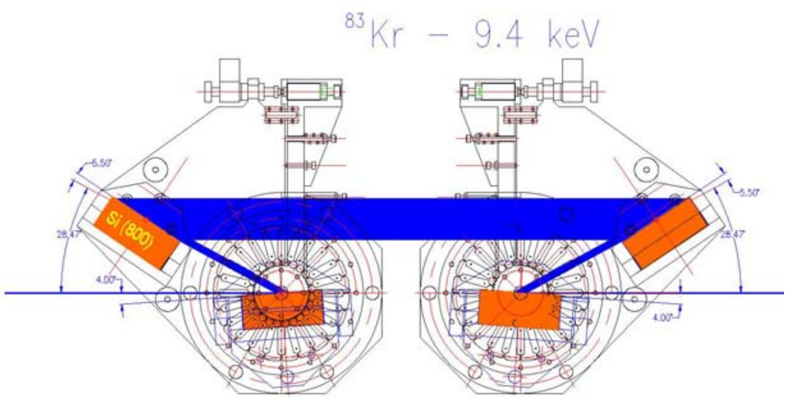
Alternative "in-line" monochromators

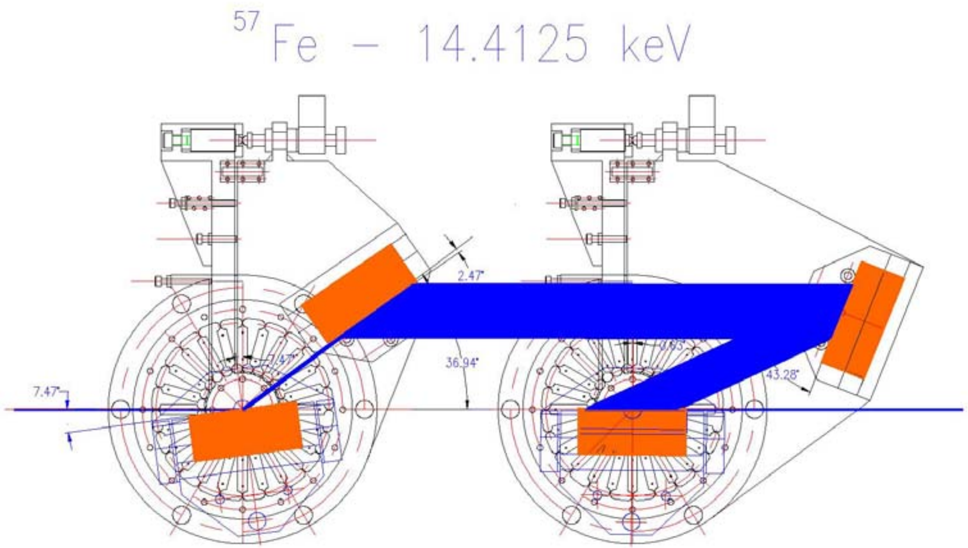




Overall reflectivity of 10-50 % is currently achievable at room temperature.

In-line mono's everywhere: 8 < E < 30 keV





E= 9.4 keV, ΔE= 1.0 meV **E= 14.4 keV, ΔE= 1.0 meV**

We plan to reach 70 % efficiency with the cryogenically cooled high resolution monochromators.

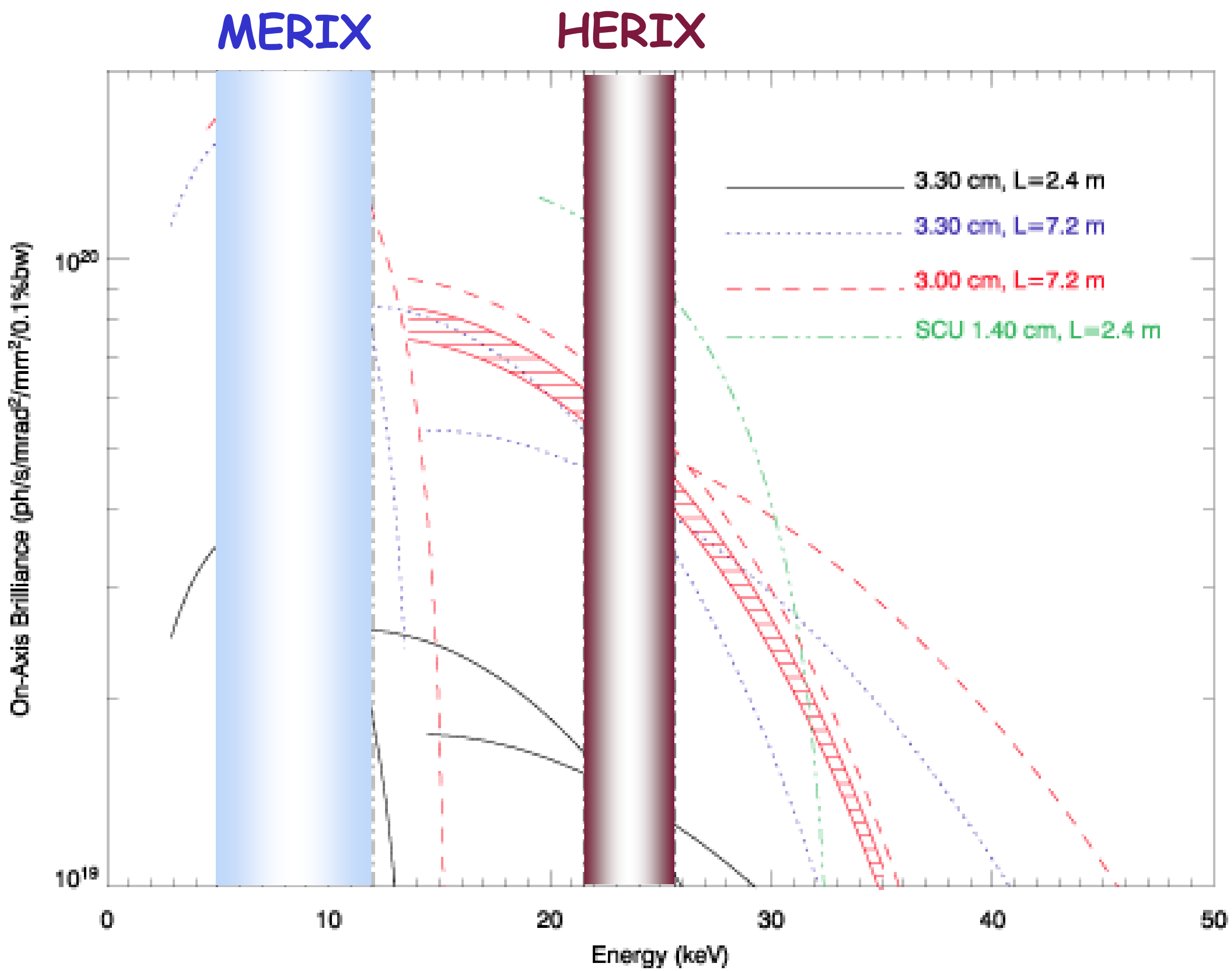
Funding

• DOE BES	5 M (1 M/year)	2002-2006
• NSF	0.9 M (0.3 M/year)	2002-2004
• Matching funds	0.65 M	

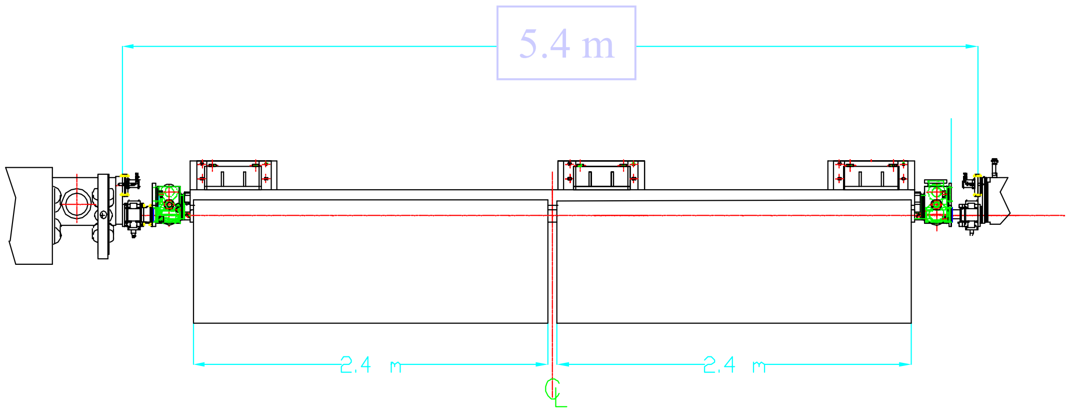
• TOTAL	6.55 M
• Estimated cost	6.45 M

(no front-end, undulator or storage ring modification cost is included)

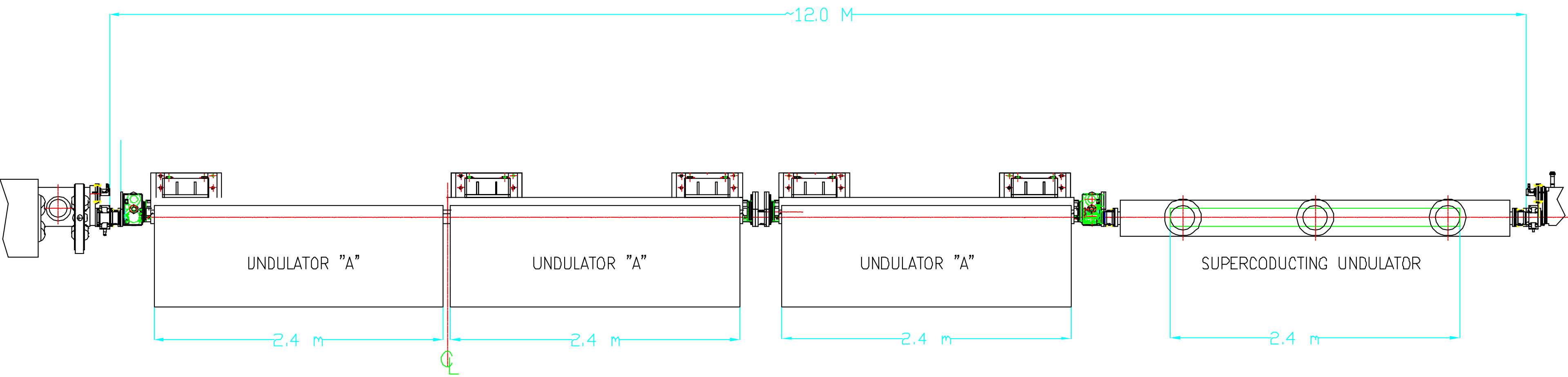
Higher Brilliance



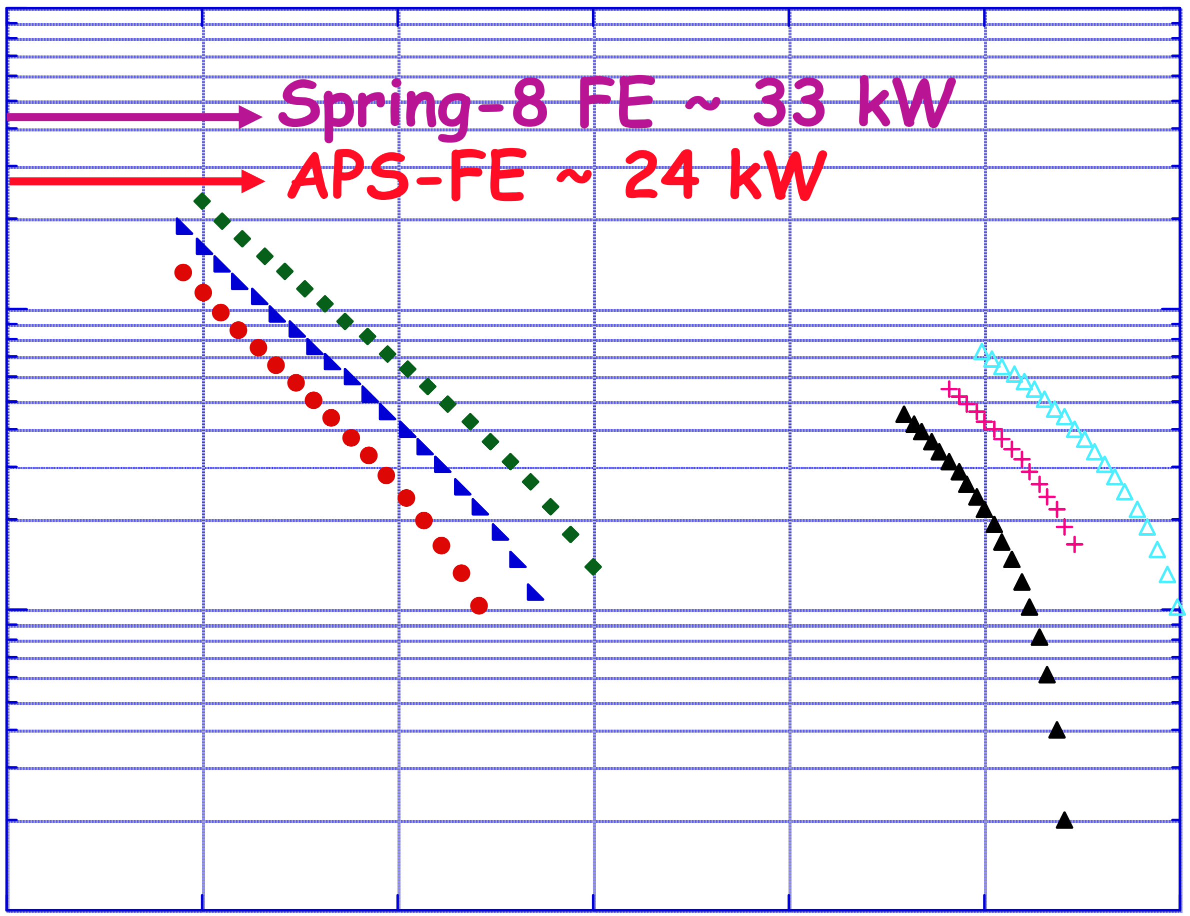
Extended Straight Section : under consideration



CURRENT STRAIGHT SECTION WITH TWO UNDULATORS "A"



LONG STRAIGHT SECTION WITH THREE UNDULATORS "A" AND ONE SUPERCONDUCTING UNDULATOR


Spring-8 FE ~ 33 kW
APS-FE ~ 24 kW

Calculated field strength (B), undulator deflection parameter (K) and minimum reachable energy (E1) in the first harmonic for undulators with different periods.

Period (mm)	B(T) 5 mm	B(T) 6.5 mm	B(T) 8.5 mm	B(T) 10.5mm	K 5 mm	K 6.5 mm	K 8.5 mm	K 10.5mm	E1(keV) 5 mm	E1(keV) 6.5 mm	E1(keV) 8.5 mm	E1(keV) 10.5mm
13	0.58167	0.37877	0.22787	0.14745	0.70605	0.45977	0.27659	0.17898	28.663	32.385	34.488	35.243
14	0.64812	0.43066	0.26384	0.17212	0.84723	0.56297	0.34489	0.22499	24.468	28.702	31.384	32.429
15	**0.71316**	**0.48288**	**0.30120**	**0.19845**	**0.99884**	**0.67632**	**0.42186**	**0.27794**	**20.705**	**25.257**	**28.498**	**29.879**
16	0.77652	0.53504	0.33961	0.22620	1.1601	0.79933	0.50737	0.33793	17.391	22.050	25.776	27.522
17	0.83801	0.58682	0.37877	0.25513	1.3302	0.93147	0.60123	0.40498	14.529	19.097	23.191	25.307
26	1.3024	1.0105	0.73198	0.53999	3.1618	2.4531	1.7770	1.3109	2.9847	4.4660	6.9425	9.6295
27	1.3448	1.0518	0.76916	0.57208	3.3903	2.6515	1.9391	1.4422	2.5553	3.8183	5.9863	8.4512
28	1.3856	1.0919	0.80570	0.60395	3.6226	2.8546	2.1064	1.5790	2.1986	3.2763	5.1654	7.4001
29	1.4249	1.1308	0.84157	0.63556	3.8583	3.0620	2.2788	1.7210	1.9011	2.8221	4.4632	6.4702
30	**1.4627**	**1.1686**	**0.87676**	**0.66686**	**4.0973**	**3.2734**	**2.4559**	**1.8680**	**1.6518**	**2.4406**	**3.8639**	**5.6533**
31	1.4991	1.2053	0.91124	0.69782	4.3393	3.4888	2.6376	2.0199	1.4418	2.1192	3.3529	4.9396
32	1.5342	1.2409	0.94503	0.72841	4.5841	3.7077	2.8237	2.1764	1.2642	1.8476	2.9172	4.3186
33	**1.5681**	**1.2755**	**0.97811**	**0.75860**	**4.8316**	**3.9301**	**3.0138**	**2.3375**	**1.1132**	**1.6171**	**2.5455**	**3.7799**
34	1.6007	1.3090	1.0105	0.78838	5.0816	4.1557	3.2079	2.5028	0.98418	1.4210	2.2279	3.3134
35	1.6321	1.3416	1.0422	0.81773	5.3339	4.3844	3.4058	2.6724	0.87356	1.2534	1.9560	2.9098

Time table

- Start of the project : 2002
- Start of construction: 2003
- Start of commissioning: 2004
- End of the project : 2006

Challenges and prospects (SUMMARY)

- Long straight section with 3 or 4 undulators
  - **Turn off Q1 quadrupole magnets, shorten dipoles**
- Superconducting undulator with K ~ 1 at 7 mm gap
  - **Shimming with extra current loops**
- Higher flux with modest K (~2) : FE heat load capacity
  - **Narrower fixed masks and reduced horizontal emittance for novel masks and shutters**
- Cryogenically cooled high resolution monochromator
  - **Temperature stability, vibration isolation: yield, resolution**

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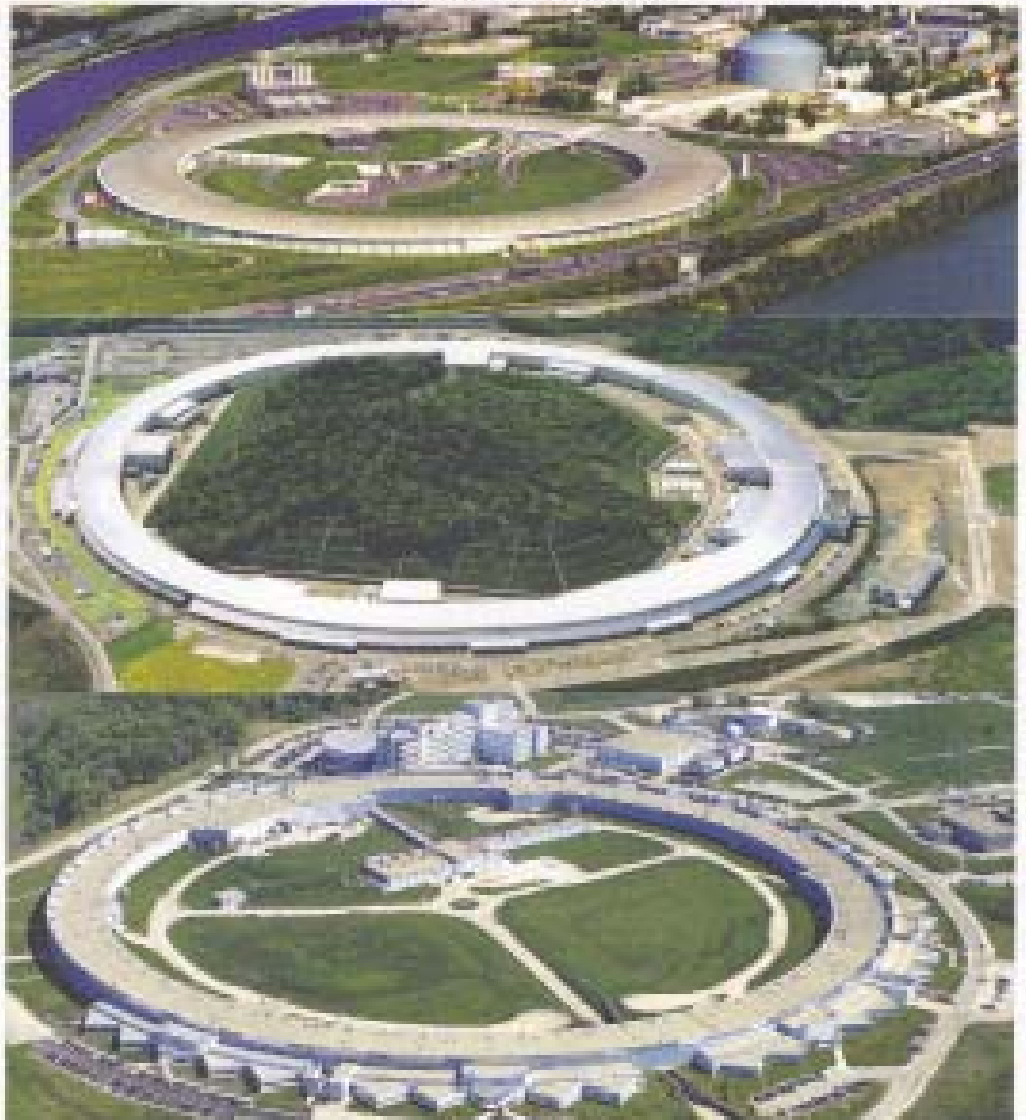

Synchrotron Radiation for Mössbauer Spectroscopy